2003022D166

AL-TR-1992-0005

EFFECTS OF PYRIDOSTIGMINE BROMIDE ON A-10 PILOTS DURING EXECUTION OF A SIMULATED MISSION: PERFORMANCE

AD-A252 309

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92 6 10 020 May 1992

Final Report for Period July 1984 – August 1991

92-15248

Approved for public release; distribution is unlimited.

HEADQUARTERS
US ARMY MEDICAL R&D COMMAND
Fort Detrick, MD 21701-5012

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The voluntary, fully informed consent of the subjects used in this research was obtained as required by AFR 169-3.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
May 1992

3. REPORT TYPE AND DATES COVERED
Final – July 1984 – August 1991

4. TITLE AND SUBTITLE
Effects of Pyridostigmine Bromide on A-10 Pilots During Execution of a Simulated Mission: Performance

5. FUNDING NUMBERS
PE – 62205F
PR – 1123
TA – 25
WU – 04

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Armstrong Laboratory
Human Resources Directorate
Aircrew Training Research Division
Williams Air Force Base, AZ 85240-6457

8. PERFORMING ORGANIZATION REPORT NUMBER
AL-TR-1992-0005

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This report documents the performance results of a study that was conducted to determine the effects of pyridostigmine bromide (PYB) (30 mg 3x/day) on pilot performance. Data was collected in an A-10 flight simulator with an Advanced Visual Technology System (AVTS). The subjects were 24 A-10 pilots who were trained on the following simulated tasks over three 55-min sessions: takeoff, patterns, emergency procedure and landing; air-to-air refueling; conventional low-angle strafing; and low-level ingress to a simulated target and threat area (RED FLAG). Next, during two test sessions, 48 h apart, the pilots were tested using a double-blind procedure on the same tasks in a PYB condition and in a placebo condition. In the two test sessions, 12 of the pilots wore chemical defense ensembles (CDE) and the other 12 wore standard flight gear (SFG). The results indicate that there are no operationally significant effects of pyridostigmine bromide that would preclude an A-10 pilot from accomplishing a tactical mission, including air-to-ground attack, under a chemical warfare threat.

14. SUBJECT TERMS
Chemical warfare, Drugs, Flight simulation, Flight simulators, Performance measurement, Pilot performance, PYB, Pyridostigmine bromide

15. NUMBER OF PAGES
48

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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PREFACE

This effort was undertaken in support of the United States Air Force (USAF) Surgeon General at the request of the Office of Military Performance Assessment Technology, Walter Reed Army Institute of Research, Washington, D.C., formerly the Joint Working Group on Drug Dependent Degradation of Military Performance (JWGD3 MILPERF). Funding for the effort was provided by the U.S. Army Medical Research and Development Command, Fort Detrick, MD. The decision was made to conduct the effort at the Aircrew Training Research Division of the Armstrong Laboratory (AL/HRA) because the A-10 mission supports Army ground operations, and the facility housed an A-10 flight simulator with an Advanced Visual Technology System.

ACKNOWLEDGMENTS

We express our appreciation to Ms Patty Lee (AL/HRAE), Ms Elzbieta Jackiewicz (UDRI), Mr Burl Griffin (AL/HRAE), and Ms Nancy Martinez (AL/HRAD) for their assistance in this effort. Ms Lee's thorough understanding of the VAX computer, in conjunction with her persistence in retrieving and formatting over 200 tapes of data made this study a reality. Ms Jackiewicz's statistical expertise and utmost patience with very troublesome data proved invaluable in the data analysis portion of this research. Mr Burl Griffin served as program engineer, and was responsible for numerous technical details that were essential to the study. Ms Nancy Martinez provided invaluable assistance in typing and conducting the final editing of this report.

A special thanks is extended to Major Charlie Stenner, Air National Guard, Air Force Reserve Test Center, Tucson, AZ, for his subject matter expertise during the data analysis phase of this research. Major Stenner's A-10 expertise, combined with his "can-do" attitude greatly expedited the data analysis effort.

EFFECTS OF PYRIDOSTIGMINE BROMIDE ON A-10 PILOTS DURING EXECUTION OF A SIMULATED MISSION: PERFORMANCE

SUMMARY

The Armstrong Laboratory A-10 flight simulator was used to determine whether the chemical warfare pretreatment drug, pyridostigmine bromide (PYB), degrades pilot performance. The Advanced Visual Technology System (AVTS) used in the study generated a full-color visual presentation with texturing. A double-blind procedure was used to orally administer PYB (30 mg, 3x/day), and a placebo (30 mg, 3x/day) to 24 A-10 pilots. The pilots were trained over three 55-min sessions on the following tasks: (1) takeoff, patterns, emergency procedure, and landing, (2) air-to-air refueling, (3) conventional low-angle strafing, and (4) low-level ingress/RED FLAG. After training, two 55 min test sessions were conducted 48 h apart. All pilots were tested in the simulator using a crossover, counter-balanced design. The pilots received either PYB or a placebo before the first session and the remaining treatment before the second session. Twelve pilots wore chemical defense ensembles (CDE) during both sessions, while the other 12 pilots wore standard flight gear (SFG). There was no indication that PYB dosage interfered with successful completion of any of the simulated tasks. The majority of the pilots wearing the CDE gear and/or while under the influence of PYB adapted to their altered state by decreasing the variability in the number and range of aircraft movements. There was no clear PYB interference with performance on the RED FLAG task except the pilots were killed 25% more frequently by surface-to-air-missiles (SAMs) under PYB. This finding may be the result of the simulation factor, i.e., the pilots would continue the mission and disregard the threat because there was no real personal danger. The only effect of being hit by a SAM or antiaircraft artillery (AAA) was a red flash of the visual. The pilot could continue the mission after the flash. The pilot's physical discomfort and view of the game as unrealistic may have caused him to focus on the main objective of the mission (to kill the command post) regardless of the number of times the simulation flashed red indicating that he died. This gaming strategy is supported by an inspection of the mean number of times the pilots were killed by SAMs. The mean for PYB with CDE is 6.98 and PYB with standard flight gear is 5.21. It is ambiguous whether or not a gear interaction was present ($F = 4.04$, $p = .056$). It is possible that this result could have been due to chance given the large number of dependent variables and respective statistical tests. There were no operationally significant effects of PYB observed in this study that would preclude an A-10 pilot from accomplishing a ground operations support mission under chemical warfare threat.

INTRODUCTION

Chemical warfare nerve agents are powerful drugs which interfere dramatically with normal bodily functions. Chemical weapons may attack the body through

overt attack or covert contamination such as poisoning water or food sources. The chief bodily portals of entry are the skin, the respiratory pathway, the eyes, and the gastrointestinal tract. Small amounts of these compounds absorbed through the skin and lungs can incapacitate or kill because they are unusually efficient in producing irreversible inhibition of the enzyme acetylcholinesterase (AChE). The result is that the neurotransmitter, acetylcholine (ACh), floods across cholinergic synapses and produces paralysis in the muscle cells controlling cardiac and respiratory activity along with other severe effects.

To counteract these effects, pretreatment drugs are administered to the aircrew before expected exposure to nerve agents. The function of a pretreatment drug is to bind reversibly the enzyme AChE before exposure to a nerve agent takes place. Reversible binding sets up a transient bond with AChE, and a temporarily protected reserve of AChE thereby becomes available to counteract the effects of chemical warfare agents. Only a small quantity of AChE, as gradually released from bonding with a pretreatment drug, is required to protect the life of an exposed person. Although these drugs provide a measure of protection from the effects of such agents, they also alter the functioning of the brain and body, albeit to a lesser degree than the nerve agents. Ideally, a pretreatment drug would have no adverse effect; but the nature of the drugs involved makes this ideal unattainable. The benefit of the pretreatment drugs must be weighed against the cost associated with undesirable side effects. The search for a safe and effective pretreatment drug in chemical warfare has focused on PYB, which was assessed to have the greatest nerve agent protection and the least side effects. Like other anti-AChE agents, PYB inhibits the destruction of ACh by the enzyme AChE. The side effects from PYB overdosage are, for the most part, classifiable as muscarinic and nicotinic. Muscarinic symptoms include nausea, vomiting, diarrhea, abdominal cramps, pupillary contraction, sweating, and increase in peristalsis, in salivation, and in bronchial secretions. Nicotinic symptoms consist mainly of changes in the musculature involving cramps, twitches in muscle groups, and weakness.

In 1983, the U.S. Army Medical Research and Development Command (USAMRDC) commenced human studies of PYB which addressed questions such as individual differences in tolerance, optimal dosages and dosage frequencies, and duration of drug action (Wannarka, 1984). This effort was expanded in July 1983 under the direction of USAMRDC into a tri-service program. A Joint Working Group on Drug Dependent Degradation of Military Performance (JWGD3 MILPERF) was formed under the leadership of Dr Frederick Hegge at Walter Reed Army Institute of Research. A comprehensive plan entitled "The Effects of Chemical Warfare Treatment Drugs on Military Performance" was developed by members of the JWGD3 representing the Army, Navy, and Air Force. The program provided an organized framework for coordinated tri-service research over a 5-year period FY84-FY89 on the effects of candidate pretreatment drugs on military performance capacity in operational environments.

The Air Force Systems Command, Human Systems Division (HSD) developed a drug screening process demonstrated by a series of studies (in-house and

contractual) that evaluated the effects of pyridostigmine bromide on military performance. The Crew Systems Directorate of the Armstrong Laboratory has conducted studies which included the development of measurement techniques and assessment of aircrew performance in stressful environments of acceleration (Boll, Whinnery, Burton, Parker, Forester & Barger, 1989; Whinnery, Burton, & Parker, 1989), altitude (Krutz, Burton, Schiflett, Holden, & Fischer, 1987; Schiflett, Stranges, Slater, & Jackson, 1987), spatial disorientation (Previc, Gillingham, Barber, and Parker 1989), and flight (Dellinger, Schiflett, & Takamoto, 1989). A unique flight test effort was conducted by the Sustained Operations Branch of the Crew Technology Division to evaluate the effects of PYB on C-130 aircrews (Schiflett, Miller, & Gawron, 1987; Gawron, Schiflett, Miller, Ball, Slater, Parker, Lloyd, Travala, & Spicuzza, 1988; Gawron, Schiflett, Miller, Slater, & Ball, 1990). The inflight mission selected simulated a low-level, air-drop flight scenario that is critical to resupplying the Army with equipment and medical supplies during a chemical warfare threat. Schiflett (1989) has summarized the research topics, references, stressors, contextual variables, drug dosages, regimen schedules, subjects, tasks, metrics, and general findings. He concludes that pyridostigmine bromide, in the dosage (30 mg/8 h) and regimens (1 to 5 days) used for these tests, provides a safe operational pretreatment for aircrews flying under a chemical warfare threat. In none of the studies, did Schiflett and his co-investigator find a significant detrimental effect of pyridostigmine on performance to preclude mission accomplishment or diminish effectiveness.

This study was conducted in the same time frame as those just cited. A companion report (Harriman, Hubbard, Brooks & Woodruff, 1989) presented the results of physiological data gathered during the study. Our report presents the results of the pilot performance. The possibility that PYB can degrade performance was explored by assessing how effectively and efficiently A-10 pilots carried out a simulated air-to ground attack mission. During execution of the simulated mission, the pilots wore either standard flight gear (SFG) or chemical defense ensembles (CDE) so that interactive effects of PYB on performance in a simulated chemical warfare environment could be better identified.

METHOD

The experiment reported in this investigation was a double-blind study of split-plot design in which there were counterbalanced presentations of the within-group treatment. Three training sessions (Sessions #1, #2, #3) preceded two test sessions (Sessions #4 and #5), separated by a 48-h interval, in which the study data were collected. The summary representation presented in Table 1 shows the between-groups factor was apparel (CDE v. SFG). One within-groups factor was dosage (PYB v. placebo tablets).

TABLE 1. SPLIT-PLOT DESIGN OF STUDY

CDE worn			versus	SFG worn		
	PYB administered				PYB administered	
Subject	Session #4	Session #5	Subject	Session #4	Session #5
A	Yes	No	M	Yes	No
B	No	Yes	N	No	Yes
C	No	Yes	O	No	Yes
D	No	Yes	P	No	Yes
E	Yes	No	Q	Yes	No
F	Yes	No	R	Yes	No
G	No	Yes	S	No	Yes
H	Yes	No	T	Yes	No
I	Yes	No	U	Yes	No
J	No	Yes	V	No	Yes
K	Yes	No	W	Yes	No
L	No	Yes	X	No	Yes

Human Use Committee

The research protocol for the study was found in conformity with AFR 169-3 (15 Jul 85), *Use of Human Subjects in Research, Development, Test, and Evaluation*, by the Air Force Human Use Committee, Bolling AFB, on 17 Dec 86, and was approved by the Air Force Surgeon General, Bolling AFB, on 18 Dec 86. Also, the protocol was found in compliance with all Department of Defense (DOD) components of DOD Directive 3216.2, protection of Human Subjects in DOD-Supported Research, by the Human Use Review Office, U.S. Army Medical Research and Development Command, Fort Detrick, MD, on 18 Feb 87. A notice of Claimed Investigational Exemption for a New Drug for permission to use PYB in tests on human volunteers was submitted to the Food and Drug Administration (FDA), Department of Health and Human Services, on 20 Jul 86. On 21 Aug 86, the FDA approved PYB as an Investigational New Drug (IND #24,480) for use with human volunteers in the study.

Subjects

The volunteers for the study were 24 mission-ready A-10 pilots who were stationed at Eielson AFB AK (12 pilots), England AFB LA (2 pilots), and Myrtle Beach AFB SC (10 pilots). Prior to the study, all of the volunteers were screened at their home bases for tolerance to PYB in conjunction with an Air Force-wide program. Also, before the pilots arrived at Armstrong Laboratory, Williams AFB AZ, to participate in the study, they were randomly assigned either to a group that wore CDE or SFG during Sessions #4 and #5. Pilots assigned to wear CDE during testing wore their own helmets and chemical defense face masks. Mean age of the pilots in the CDE group was 29.0 with a standard deviation (SD) of 3.1 years, and mean body weight was 77.9 kg with SD 9.4 kg. Matching values for the SFG group were 29.5 with a SD of 4.6 years and 87.1 kg with a SD of 9.2 kg.

At the time the pilots volunteered for the study, they were informed that the primary benefits of the study were for the defense posture of the United States and that the Air Force commitment to conduct the study was made with this intention. The pilots were also informed, however, that there were individual benefits for the participants. Among these benefits was the opportunity to practice a variety of flight-related activities in a "state-of-the-art" A-10 flight simulator. Another benefit for 50% of the participants was the opportunity for experience in flying a simulated mission while wearing CDE. Also, the exposure to PYB would provide feedback to each participant on individual flying skills before an actual combat mission under a chemical warfare threat.

Apparatus

Simulator

The flight simulator used in the study was the Armstrong Laboratory's A-10 flight simulator. A list of operational cockpit instruments and graphic displays of the layout of the cockpit may be found in Appendix B. The simulator does not have a motion system. The G-seat and G-suit were not used in this study.

Visual

The Advanced Visual Technology System (AVTS) is a 10-channel Computer Image Generator (CIG), capable of generating 6,000 edges, 4,000 point features, 1,000 circular features, and seven moving models every 33.3 ms. All 10 channels support texturing, a feature which provides motion and altitude cues considered essential for low-level flight and other air-to-surface missions. Ferguson, Cody, and Petrie (1986) have documented system specifications for the AVTS. The AVTS full-color visual imagery was displayed in a dodecahedron equipped with color light valves.

Database

Based on real-world data from the Defense Mapping Agency (DMA), a 10,000 square nautical miles (nm^2) area was modeled. Included in this database was Nellis Air Force Base NV, and the nearby RED FLAG ranges. This AVTS database represents as accurately as possible, within the constraints of the system, the actual geographic areas. Detailed specifications of this database may be found in Ferguson, Cody, and Petrie (1986) technical paper.

Performance Measures

The basic element in the performance measurement system was a VAX 11/780 system (Digital Electronic Corporation) for storage of the behavioral data. Software needed for acquisition of the data recorded on the VAX was developed by a contractor to the Armstrong Laboratory.

Tasks

The scenario used throughout the study was a "mission" of 55-min duration divided among four segments as follows: (1) takeoff and "pattern" work with an embedded emergency procedure (15 min), (2) inflight aerial refueling (AAR) from a simulated tanker (8 min), (3) conventional low-angle strafing (12 min), and (4) low-level ingress/RED FLAG (20 min). All of the events took place in a visual environment over realistically modeled land masses and specific terrain areas of the Nellis/RED FLAG Range areas of Nevada. The RED FLAG range is used by the Air Force to simulate a tactical training environment including tactical targets and threats, such as AAA and SAMs. Realistic types and concentrations of aircraft, targets, and threats were programmed into the different segments.

Task 1 - Takeoff/Patterns/Engine-Out/Landing

The pilot took off from Nellis AFB, climbed to 4,000 ft mean sea level (MSL), and leveled off. The pilot completed the pattern with feedback from the instructor/operator station and did a "touch and go." On the second pattern, the pilot "lost" an engine and had to take appropriate action to land the plane. Time allotted for this task was 15 min. The simulator froze at the end of 15 min, and the visual display cleared of all computer image generated (CIG) imagery.

Task 2 - Air-to-Air Refueling

In this task, the pilot rendezvoused with a KC-135 tanker and attempted to refuel. The simulator was reinitialized with both engines working properly

for the duration of this task. At the point of initialization, the pilot was 1,000 feet behind a KC-135 moving at 200 knots with a working boom. The pilot tried to adjust the flight parameters to match those of the tanker and to hook up and to take on as much fuel as possible. At 8 min, regardless of refueling success, the visual display was cleared, and the simulator was put on freeze.

Task 3 - Conventional Low-Angle Strafing

For the third task, the pilot strafed a target on a conventional gunnery range from a visual low-angle pattern. The Nellis conventional range layout was modeled for this task. The pilot strafed the target as many times as possible during the 12-min session. Pilots received feedback on percontage of hits at the end of each pass.

Task 4 - Low-Level Ingress/RED FLAG

The pilot was initialized for low-level penetration into a tactical target area. In the initial part of the segment, the pilot navigated a preplanned route of 30 nautical miles to the target area at an altitude of 50-500 ft above ground level (AGL). At the initial point (IP), the pilot proceeded into the target/threat area with the intention of destroying the command post. From this point, the pilot was subjected to threats from AAA and SAMs as a realistic function of attack tactics. After attacking the command post, the pilot could make additional passes or go on to attack three other target areas. The pilot continued to be susceptible to threats. When a target was hit, a smoke plume appeared in the visual scene over the target to indicate a kill. The AAA and SAMs could also be killed. When the pilot was "killed" by AAA, SAM, or ground collision, the visual scene turned red for a fraction of a second and the mission continued. If a simulator malfunction occurred in the target area, the pilot was restarted at the IP. If a malfunction occurred during low-level ingress, the pilot was initialized at the nearest checkpoint. After 20 min, the session terminated. Complete details on these tasks may be found in Appendix C.

Measurements

Performance

The measures recorded that were common to all four segments were as follows: aircraft position, acceleration, velocity, pitch, roll, yaw, and control inputs. The segment specific measures included the following: (refueling) time connected with boom and number of disconnects; (strafing) airspeed, G-loadings, range at open fire, range at cease-fire, number of rounds fired, number of hits, and number of crashes; (RED FLAG ingress) airspeed, G-loadings, and number of crashes; (RED FLAG target area) airspeed, G-loadings, number of kills, number of times killed, number of rounds fired, range at open fire/cease

fire, number of engagements, and number of times threats in range detected. A complete list of all measures recorded for each task may be found in Appendix D.

Procedure

Three items that described the aims of the study and required duties of the participants during the different 5-day periods of data collection were mailed to prospective volunteers. The items were as follows: (1) an invitation from the Armstrong Laboratory to prospective subjects that explained the aims of the study; (2) an informed consent form that further explained the study goals and described how PYB affects the nervous system and what might be the side effects of the drug, and (3) a day-to-day schedule of each participant's activities in the investigation.

After arriving at Williams AFB, the pilots participated without deviation in all iterations of the experimental procedure over successive 5-day test periods.

Sunday

One of the researchers associated with the study met each group of three pilots at the time the volunteers checked in at Williams AFB. The researcher answered questions concerning the mailings and familiarized the pilots, as needed, with the location of base facilities. The pilots were instructed to fast (except for water) for the 8-h period preceding their appearance at the Williams AFB USAF Hospital at 0600 on the following day.

Monday

Upon arrival at the hospital, the pilots were screened for tolerance for PYB. A flight surgeon assigned to the study discussed the risk factors for participants in the study and supervised signing the informed consent statements. Then, whole blood (7.5 milliliters [ml]) was obtained from each pilot who next took one (oral) 30 mg PYB tablet (Mestinon, Hoffmann-LaRoche, Inc.). During the next 2 h, the group heard a videotaped lecture on the flight scenario and had questions concerning the study answered by personnel assigned to the study. Two hours after the PYB tablets had been taken, the pilots underwent a second 7.5 ml blood draw.

At 0930, 1030, and 1130, the three A-10 pilots in the group of volunteers individually and successively, undertook a "familiarization" session (Session #1) in the A-10 flight simulator. Each flight was carefully supervised by one of the researchers in the Instructor Operator Station (IOS) who used a two-way communication system in closely monitoring and guiding the performance of each pilot. The procedure was repeated with the different pilots at 1330, 1430,

and 1530. In Session #2, however, the amount of feedback given to the pilots on their performance, though tailored to the individual, was significantly reduced.

Tuesday

Session #3, the last of the training sessions, was conducted with the pilots at 0800, 0900, and 1000, respectively. The experimenter held feedback on performance to the minimum while the three pilots individually repeated the run through the scenario.

Thereafter, a USAF flight surgeon supervised the first of two series of double-blind administrations of PYB and placebo tablet (30 mg, 3x/day) with the pilots. If PYB tablets were taken in the first series, then in the double-blind procedure, placebo tablets were taken in the second series. Administrations of the tablets began with the different pilots at 1500, 1630, and 1800, respectively, and continued until each pilot had taken three tablets at 8-h intervals.

Wednesday

The pilots reported to the research area 30 min before the start of Session #4. At that time, the pilots were questioned in detail concerning their food and fluid intakes over the preceding day. Before the session, physiological recording devices were attached to the pilots as described in Harriman, Hubbard, Brooks, and Woodruff (1989). The pilots either wore SFG (50% of the pilots) or wore CDE (the other 50%) in Session #4 which began for the different pilots at 0830, 1000, and 1130. In this arrangement, each pilot began the session 1.5 h after the third tablet in the first series of administrations had been ingested.

Thursday

None of the pilots were tested on this day, allowing time for drug clearance from the body to occur among the pilots who had been given PYB in the first series of three tablets. The USAF Flight Surgeon supervised the second series of double-blind administrations of tablets (30 mg, 3x/day) to the three pilots. The pilots followed the same schedule in taking the tablets that had been used with the first series of tablets.

Friday

The procedure followed in conducting Session #5 repeated that followed with Session #4. Thus, the pilots were tested while wearing the same apparel in both sessions of data collection. The code to the double-blind procedures was broken after the last of the three pilots who were tested in a given week

had completed Session #5. The three pilots and the experimenters then learned the order in which the pilots had received the three PYB tablets and the three placebo tablets. At this point, upon the approval of the Flight Surgeon, the pilots were released.

RESULTS

Dependent Measures

The full list of dependent measures may be found in Appendix C. These variables were recorded by the simulator at 30 Hz and were reduced to means and standard deviations within each task or task segment. Since the majority of these variables did not reach statistical significance (at an alpha of .05), only the statistically significant results will be reported.

Experimental Design

The basic design of the study was a split-plot with one between-subject factor, Gear (Standard Flight Gear [SFG] vs. Chemical Defense Ensemble [CDE]) and one within-subject factor, Drug (Pyridostigmine Bromide [PYB] vs. placebo). The design was counterbalanced with half of the subjects in each of the Gear conditions beginning their testing with PYB and the other half beginning with placebo. This design was analyzed separately for each task.

Task 1 - Takeoff, Pattern Work, Full-Stop Landing with One Engine Out

There was only one significant effect observed in this task, a significant Gear by Drug interaction ($F[1,21] = 6.11$, $p = .022$) for the Standard Deviation of Aircraft Altitude as seen in Table 2.

TABLE 2. STANDARD DEVIATION OF AIRCRAFT ALTITUDE (TASK 1)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	245.29	269.28	286.53	255.39
Stderr	11.35	11.86	11.35	11.35
N	12	11	12	12

Task 2 - Aerial Refueling

There was only one significant effect observed in this task. Table 3 shows a significant Gear by Drug interaction was observed for the Standard Deviation of the Log (Base 2) of Vertical Deviation from the Ideal Refueling Position ($F[1,22] = 4.54$, $p = .045$).

TABLE 3. STANDARD DEVIATION OF THE LOG (BASE 2) VERTICAL DEVIATION FROM THE IDEAL AERIAL REFUELING POSITION (TASK 2)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	1.19	1.48	1.53	1.21
Stderr	0.14	0.14	0.14	0.14
N	12	12	12	12

Task 3 - Conventional Low-Angle Strafe

The subjects performed multiple passes. The proportion of shots fired that struck the center of the target and the proportion that hit the target (but not the center) were analyzed. Of the proportion hitting the center, (see Table 4), there was a Gear effect ($F[1,22]) = 5.97$, $p = .023$) for the standard deviation, but not the mean (i.e., the mean accuracy was not different for the two gear conditions but the variability from pass to pass was greater). The mean proportion of hits outside the target center was significant for the Gear by Drug interaction ($F[1,22] = 4.33$, $p = .049$) as shown in Table 5. The standard deviation was significant for the Drug effect ($F[1,22] = 4.64$, $p = .042$) as shown in Table 6. None of the other measures were significant.

TABLE 4. STANDARD DEVIATION OF PROPORTION OF HITS IN THE CENTER OF THE TARGET (TASK 3)

	GEAR	
Effect Levels	**Gear**	**No Gear**
Mean	0.09	0.15
Stderr	0.02	0.02
N	24	24

TABLE 5. MEAN PROPORTION OF HITS ON TARGET OUTSIDE CENTER (TASK 3)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	0.67	0.76	0.67	0.63
Stderr 0.03	0.03	0.03	0.03	
N	12	12	12	12

TABLE 6. STANDARD DEVIATION OF PROPORTION OF HITS ON TARGET OUTSIDE THE CENTER (TASK 3)

	DRUG	
Effect Levels	**Drug**	**Placebo**
Mean	0.32	0.28
Stderr	0.01	0.01
N	24	24

Task 4 - Low-Level Ingress/RED FLAG

This task was divided into two sections, the low-level ingress and RED FLAG sections. The ingress section was further divided into three legs defined by the two identical points and the entrance to the RED FLAG area.

Ingress - Leg 1. The only Drug effect noticed on the first leg of the ingress was in the Mean Deviation of Above Ground Level Altitude (F[1,20] = 5.94, p = .024) (see Table 7). Other than the Drug effect, a Gear by Drug interaction was noted for the Mean Ground Acceleration (F[1,20] = 5.60, p = .028) (see Table 8), and the Mean Control Stick Pitch (F[1,20] = 4.92, p = .038) (see Table 9). All other effects were not statistically significant.

Ingress - Leg 2. For the second leg of the ingress, no significant effects were noted.

TABLE 7. MEAN OF DEVIATION OF AGL ALTITUDE FROM TARGET AGL FOR LEG 1 OF THE LOW-LEVEL INGRESS (TASK 4)

	DRUG	
Effect Levels	**Drug**	**Placebo**
Mean	-75	-134
Stderr	14	14
N	23	23

TABLE 8. MEAN GROUND ACCELERATION FOR LEG 1 OF THE LOW-LEVEL INGRESS (TASK 4)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	5.2	3.5	2.9	3.4
Stderr	0.5	0.5	0.5	0.5
N	11	12	12	11

TABLE 9. MEAN STICK PITCH FOR LEG 1 OF THE LOW-LEVEL INGRESS (TASK 4)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	0.436	0.465	0.475	0.468
Stderr	0.009	0.008	0.008	0.009
N	11	12	12	11

Ingress - Leg 3. For the last leg of the ingress, the one preceding entry into the hostile RED FLAG area, the observed Drug effects were in the Standard Deviation of Acceleration ($F[1,20] = 13.10$, $p = .002$), (see Table 10), the

Standard Deviation of Ground Acceleration (F[1,20] = 6.28, p = .022), (see Table 11), the Standard Deviation of Vertical Acceleration (F[1,20] = 4.56, p = .047), (see Table 12), and the Standard Deviation of the Right Throttle (F[1,20] = 8.18, p = .010), (see Table 17). A Gear by Drug interaction was noted for Standard Deviation of Vertical Velocity (F[1,20] = 6.09, p = .024), (see Table 13), Mean Vertical Acceleration (F[1,20] = 6.37, p = .021), (see Table 15), Standard Deviation of Pitch Angle (F[1,20] = 5.19, p = .035), (see Table 14), and the Standard Deviation of Right Throttle Setting (F[1,20] = 5.14, p = .036), (see Table 16).

TABLE 10. STANDARD DEVIATION OF ACCELERATION OF LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4)

	DRUG	
Effect Levels	**Drug**	**Placebo**
Mean	5.78	8.06
Stderr	0.53	0.56
N	23	21

TABLE 11. STANDARD DEVIATION OF THE GROUND ACCELERATION FOR LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4)

	DRUG	
Effect Levels	**Drug**	**Placebo**
Mean	3.47	4.72
Stderr	0.51	0.53
N	23	21

RED FLAG - Target Area. The only significant effects in the RED FLAG target area were for Drug. They are, a count, adjusted for the amount of time spent in the target area, of the times the subject was "killed" by SAMS (F[1,22] = 4.75, p = .040), (see Table 18), and the dichotomous variable indicating whether or not the command post was killed (F[1,22] = 6.82, p = .016), (see Table 19). All other effects were not significant.

TABLE 12. STANDARD DEVIATION OF VERTICAL ACCELERATION FOR LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4)

	DRUG	
Effect Levels	**Drug**	**Placebo**
Mean	5.93	7.54
Stderr	0.52	0.55
N	23	21

TABLE 13. STANDARD DEVIATION OF VERTICAL VELOCITY FOR LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	18.28	18.18	17.66	20.15
Stderr	0.64	0.64	0.62	0.68
N	11	11	12	10

TABLE 14. STANDARD DEVIATION OF THE PITCH ANGLE FOR LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	1.71	1.71	1.64	1.88
Stderr	0.06	0.06	0.06	0.07
N	11	11	12	10

TABLE 15. MEAN VERTICAL ACCELERATION FOR LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4)

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	0.51	0.43	0.53	0.89
Stderr	0.10	0.10	0.10	0.11
N	11	11	12	10

TABLE 16. STANDARD DEVIATION OF THE RIGHT THROTTLE FOR LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4) DRUG BY GEAR INTERACTION

	GEAR * DRUG			
Effect Levels	**Gear & Drug**	**Gear & Placebo**	**No Gear & Drug**	**No Gear & Placebo**
Mean	.041	.043	.043	.075
Stderr	.008	.008	.008	.008
N	11	11	12	10

TABLE 17. STANDARD DEVIATION OF THE RIGHT THROTTLE FOR LEG 3 OF THE LOW-LEVEL INGRESS (TASK 4) MAIN EFFECT DRUG

	DRUG	
Effect Levels	**Drug**	**Placebo**
Mean	.042	.058
Stderr	.018	.018
N	23	21

TABLE 18. NUMBER OF TIMES KILLED BY SAMS (TASK 4)

	DRUG	
Effect Levels	Drug	Placebo
Mean	6.09	4.54
Stderr	0.51	0.51
N	24	24

TABLE 19. PROBABILITY OF KILLING THE COMMAND POST (TASK 4)

	DRUG	
Effect Levels	Drug	Placebo
Mean	0.92	0.63
Stderr	0.08	0.08
N	24	24

DISCUSSION

The relatively low PYB dose of 30 mg/8 h used in this study, as compared to therapeutic doses up to 200 mg/8 h to treat various clinical disorders, were not expected to have any detrimental effects on operationally relevant tasks. However, because of the criticality of the A-10 support mission to an advancing mechanized Army under chemical warfare threat, it was imperative that a full high fidelity simulation be conducted to evaluate any subtle effects of PYB taken as a pretreatment drug would have on pilot performance and physiology. Retrospectively, this was an important decision by the Air Force Surgeon General to request this research prior to facing a real chemical threat during the recent Middle Eastern conflict with Iraq. This research study was unique in that it was the only study combining chemical defense ensembles (suit, mask, hood, and gloves), PYB, realistic A-10 flight simulation, biochemical analysis, and placebo controls to assess mission impact prior to actual combat conditions.

Within a wide range of pilot performance measurements, there was no indication that PYB dosage interfered with successful completion of the following simulated mission relevant tasks:

Task 1 Takeoff, Pattern Work, Full-Stop Emergency Landing with One Engine Out
Task 2 Aerial Refueling
Task 3 Conventional Low-Angle Target Gunnery Strafe
Task 4 Evasive Terrain Following Ingress into Ground Targets Protected by SAMs and AAA weapons

However, to properly interpret the performance data, these results should be placed in the context of the physiological state of the pilot during specific phases of the mission. In the companion report by Harriman, Hubbard, Brooks, and Woodruff (1989), it was found that the mean heart rates, and heart rate/respiratory rate ratios of the 12 pilots wearing CDE were significantly lower under PYB, particularly when the tasks were rated low in difficulty (minimal workload). Significant trends in the data also revealed that cumulative increases in skin temperature were clearly related to the inability of the pilot to dissipate heat in the CDE gear. The heat stress load was further increased due to inefficient alterations in the thermoregulatory system due to the interactive effects of PYB with CDE gear.

Not only does the CDE gear and PYB interact to alter physiological parameters, it may diminish activation and mood states leading to decrements in performance. In an extensive review of the literature, Kelly, Sucec, and Englund (1988) summarized several laboratory and field studies that showed a suppression of affective states while wearing CDE gear. It was further found in the review that wearing CDE gear versus standard military clothing lowered morale (measured by mood scales) over a 12-h exposure. However, performance degradation of decreased accuracy on serial math, target detection, logical reasoning, and reaction time were present within the first 4 h of testing and most within the first hour (Kelly, Englund, Ryman, Yeager, & Sucec, 1987). Additional insight into the thermal effects of CDE on operational performance and adapting to increasing task demands can be found in Ramirez, Kayle, Crowley, Derringer, Miller, & Baker (1988).

When the pilot is subjected to internal and external stressors of restricted peripheral vision, low heart rate, suit confinement, heat load, and a change in mood state, it is clearly evident that the majority of the pilots wearing the CDE gear and/or while under the influence of PYB adapted to their altered state by decreasing the variability in the number and range of movements. For example, the most dominant trend in the performance data, as detailed in the results section and summary page of this report, is a reoccurring *decrease* in the standard deviation of several inflight dependent measures leading up to the RED FLAG mission Task 4. The pilots were more consistent in meeting task demands while performing touch-and-go patterns and handling engine cut emergencies during Task 1. The pilots also showed less variability in vertical deviation when performing the aerial refueling Task 2, possibly because of the "centrally attentive vision" due to the restrictive mask and hood combination as noted by Harriman, et al. (1989).

The final scenario (Task 4) was to fly three low-level (50 - 500 ft AGL) terrain following ingress legs into the main target objective and destroy the Command Post (CP). The pilots responded in the same behavioral pattern by *reducing* variability (lower standard deviations) within two interrelated acceleration flight parameters, vertical G and ground G forces. This finding further supports the general conclusion that the pilot has a diminished range of responses, i.e., less deviations in altitude and acceleration. This lack of variation in maneuverability seems to have placed the pilots in a "successful" position to destroy the CP more often (22 out of 24 times) under PYB than placebo (15 out of 24 times.) Examining the data in Table 17 from another perspective, there is a 32% increase in the probability of destroying the CP while a pilot is under the influence of PYB (.92) than when the same pilot is flying under placebo conditions (.63).

However, there are consequences to the pilot's compensatory actions. The pilot is now in hostile enemy territory with only guns available, no chaff, flares, or electronic countermeasures (ECM). The results clearly show in Table 18 that the pilots were killed 25% more frequently by SAMs under PYB (6.09 times) than placebo (4.54 times). The standard error of measurement was relatively low (.51). These significant differences in frequency of "kills" were only for the SAM sites and not for AAA batteries or kill ratios for SAMs or AAAs to pilot kills. All the pilots had the same amount of time (20 min) allocated for Task 4 (Ingress and RED FLAG). No significant differences were observed for amount of time spent in the RED FLAG area. Nevertheless, all variables were adjusted for time spent in the RED FLAG target area.

Retrospectively, these performance data results must be interpreted with full knowledge of the physiological and psychological state of the pilot and how that affects his strategy to "win the wargame." For example, from the pilot's perspective, several unrealistic conditions were prevalent in this otherwise high fidelity simulation. The pilot had unlimited rounds of ammunition to "kill" the command post and he could die from hostile fire and still play the game although it was "scored against him." When he was locked on by a SAM, he could try to evade because this was his only alternative since he had no countermeasures. The evasive maneuver would result in greater variability in altitude and acceleration. Regardless of this success in evading the threat, he would live to fight again.

The data supports the hypothesis that under PYB, the pilots did not decide to adopt an evasive strategy possibly because of physical discomfort and a view of the game as unrealistic. Therefore, the pilot focused on the main objective of the mission to "kill" the CP and get out of the game regardless of the number of times the simulation flashed a red signal that he died. This "gaming" strategy interpretation is further supported by an inspection of the killed-by-SAMs means of PYB with CDE (6.98) and PYB with the standard flight suit (5.21). There may have been a Drug X Gear interaction ($F=4.04$, $p=.056$).

It is possible that this Drug main effect and Drug X Gear interaction could have been due to chance, given the large number of dependent variables and respective statistical tests. Given the small number of statistically significant results, and the large number of operationally insignificant differences between pilot performance outcomes, the following conclusions and recommendations are offered as tentative guidelines.

CONCLUSIONS AND RECOMMENDATIONS

Based on these results, there are no operationally significant effects of pyridostigmine bromide that would preclude an A-10 pilot from accomplishing a ground operations support mission under a chemical warfare threat. This conclusion is additionally supported by actual *inflight* performance studies reported by Gawron, Schiflett, Miller, Slater, & Ball (1990), using C-130 pilots, Whinnery (1985), using F-4 National Guard pilots, and preliminary data from "lessons learned" briefings after Operation Desert Storm. Additional PYB reference material may be found in the Bibliography in Appendix D.

In addition, we recommend that heat stress studies be conducted before administering PYB inflight to pilots wearing full CDE gear with protective gloves. The study should be conducted on an Air Force flight range or during an actual A-10 close air ground support mission exercise to examine the possible interactive effects of heat stress and chemical defense flight ensembles on the pilot's ability to accomplish mission critical tasks.

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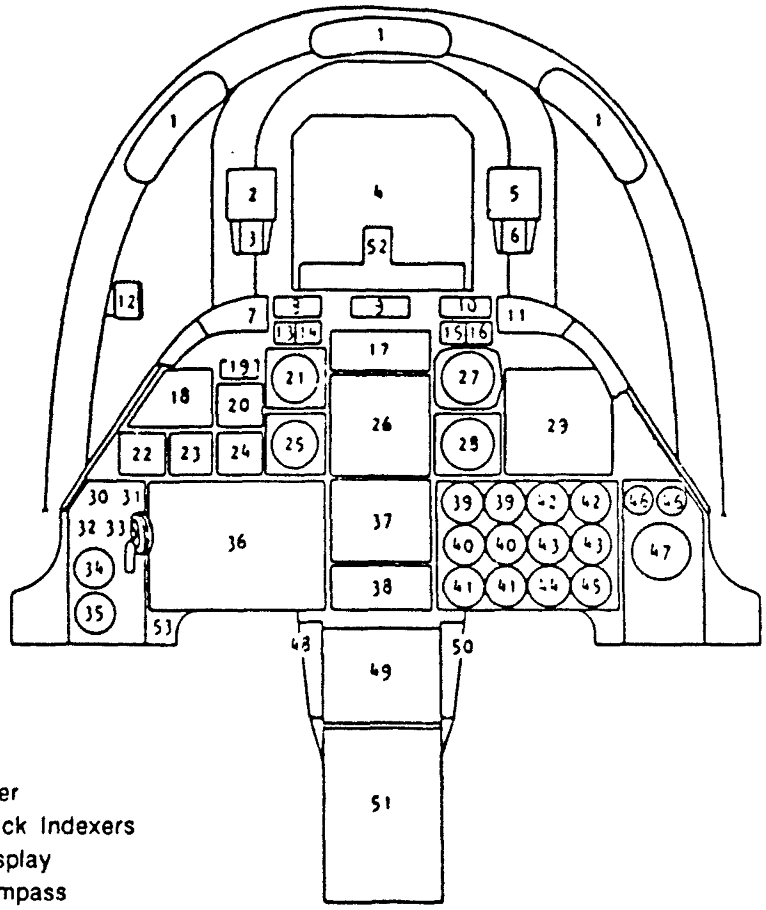
APPENDIX A: A-10 OPERATIONAL INSTRUMENTS AND COCKPIT LAYOUT



2. Accelerometer
3. Angle-of-Attack Indexers
4. Head-Up Display
5. Standby Compass
13. Gun Ready Light
14. Nosewheel Steering Engaged Light
17. Radar Warning Receiver Control Indicator
19. Master Caution Light
20. Standby Altitude Indicator
21. Radar Warning Receiver Azimuth Indicator
24. Angle-of-Attack Indicator
25. Airspeed Indicator
26. Altitude Director Indicator
27. Vertical Velocity Indicator
28. Altimeter
32. Landing Gear Position Display
33. Landing Gear Handle and Override Button
34. Flap Position Indicator
37. Horizontal Situation Indicator
38. Navigation Mode Select Panel
39. Interstage Turbine Temperature Indicator (L and R)
50. Rudder Pedal Adjustment Handle

APPENDIX B: SCENARIOS

The following tasks were performed in the simulator: (1) Takeoff, pattern work, engine out; (2) aerial refueling; (3) strafe; and (4) low-level ingress, RED FLAG. Each pilot was briefed as follows for each of the four tasks.

Task 1: Takeoff, Pattern Work, Engine Out (15 min)

a. First Pattern

The initial condition is on Runway 3 at Nellis AFB, Nevada, at a dead stop. The field evaluation is 1,868 feet Mean Sea Level (MSL). You will be under visual flight rules (VFR). Tactical Air Navigation (TACAN) is not available. You will have the Instrument Landing System (ILS) course and glideslope to help you on final as desired. Make your normal takeoff and accelerate to 250 knots. At 2,900 feet MSL, start a left turn to a heading of 300 for a crosswind leg and level-off at 4,000 feet MSL. Shortly after establishing the crosswind, you will see two fairly thick parallel white lines angling in front of you. They represent a large powerline right-of-way. Turn to a heading of 210 for a downwind just before crossing the powerlines. Within 30 seconds after rolling out on downwind, you will see a green area in front of you and to the right that represents a golf course. It is the primary reference for your downwind track. Fly slightly to the left of it. Continue on past the golf course about 1 more minute and you will see a black line angling across in front of you. This represents a major road. Turn to base just before you cross it. You will see some figures which represent Las Vegas hotels in the distance (the closer, left-hand group). Aim just to the right of them on your base heading of 120°. Turn to final, heading 030, shortly after you fly past the hotels or use the Course Deviation Indicator (CDI) to make a course intercept on the 028 radial. Once you roll out, you will soon be able to see two small red lights in the distance. These are at the near end of the runway. Aim for the one on the left if you see them. This should put you on a 7-nautical-mile final. You will fly over a large green area on final about 5 nautical miles out. Check to see that your gear is down. Proceed visually once you pick up the runway/base environment and do a touch-and-go.

b. Second Pattern

Do the same thing you did last time, except this time you can expect to experience an engine problem in the area of the golf course downwind. Handle the problem as you normally would. Check to see that the following switches are off: Auxiliary Power Unit (APU) generator, APU start, and crossfeed. Be sure the Stability Augmentation System (SAS) is on. Check to see that the gear is down. Fly the remainder of the pattern to a full-stop landing using whatever techniques you would expect to use in the real world.

Task 2: Aerial Refueling (8 min)

The initial condition is 1,000 feet behind the tanker, which is at an altitude of 16,000 feet and moving at approximately 200 knots. The probe is in the nose. The objective is to hook up and take as much fuel as possible.

Task 3: Conventional Low-Angle Strafe (LAS) (12 min)

The target that you will be shooting at will be the leftmost target in the right-hand pit. Squeeze the trigger and watch to make sure the rounds impact the center of the target. For the conventional strafe runs, you will be initialized on a base leg at 5,500 feet MSL, heading

approximately 080 degrees, at 300 knots to do a left-hand pattern. The target areas or strafe pits will be in your left ten-o'clock position and show up as two fairly large rectangular areas that are darker colored than the surrounding terrain. You have unlimited rounds. Your goal is to get the highest percentage (not just hits) in the 12 minutes allotted. You will be given feedback on the total percent for that pass only.

Task 4: Low-Level Ingress/RED FLAG (20 min)

In the RED FLAG segment, you have no chaff, flares or Electronic Countermeasures (ECM). Your only weapon is the gun. You have unlimited bullets. This is a model of the real-world Nellis range. Terrain elevation at the start point is approximately 5,400 feet MSL. As you fly the low-level, try to maintain an altitude of 50-500 feet Above Ground Level (AGL). Observe that the bearing pointer is aligned with heading. It points to the steer point and updates to the next steer point automatically as each is overflown until the command post is reached. Then, it will point to the command post. There is no distance-to-steer-point readout available. The route has been planned for 350 knots. You need to do a system test on the Radar Warning Receiver (RWR) prior to entering the target area. For leg one, the heading is 248° for 20 nm. For leg two, the heading is 197° for 15.5 nm. For leg three, the heading is 260° for 14 nm. From the Initial Point (IP), the heading is 220° for 8 nm. The targets are located in the smaller, northernmost salt flats in the Kawich Valley between Belted Peak and Quartzite Mountain. The target area elevation is approximately 5,300 feet. Additional targets include the following:

a. Kawich Airfield. Located about 180° south of command post (approximately 7 nm).

b. Airborne Regiment. Located about 90° east of command post (approximately 1.5 nm).

c. Industrial Complex. Located southeast of Kawich Airfield. Target is downstairs center of northeast building.

d. Both SA-4 sites.

APPENDIX C: PERFORMANCE MEASURES

RAW SIMULATOR DATA RECORDED DURING TASK ONE
CHEMICAL WARFARE DEFENSE STUDY

Task One: Fifteen (15) minutes duration Take off from Nellis AFB, fly a prescribed flight pattern at 4,000 feet MSL, perform a touch-and-go at Nellis AFB, repeat the pattern, and experience a mid-air engine failure and then perform a single-engine landing at Nellis AFB.

WORD	DATAPOOL NAME	TYPE	PARAMETER DESCRIPTION
1	WNALATDP	ED	A/C LATITUDE (FIRST WORD)
2			" (SECOND WORD)
3	WNALONDP	ED	A/C LONGITUDE (FIRST WORD)
4			" (SECOND WORD)
5	AFHGEO	EW	A/C ALTITUDE
6	AFUE	EW	A/C X VELOCITY (EARTH)
7	AFVE	EW	A/C Y VELOCITY (EARTH)
8	AFWE	EW	A/C Z VELOCITY (EARTH)
9	AFDUE	EW	A/C X ACCELERATION (EARTH)
10	AFDVE	EW	A/C Y ACCELERATION (EARTH)
11	AFDWE	EW	A/C Z ACCELERATION (EARTH)
12	AFGTHETA	EW	A/C PITCH ANGLE
13	AFGPHI	EW	A/C ROLL ANGLE
14	AFGPSI	EW	A/C YAW ANGLE (HEADING WRT TRUE NORTH)
15	BSCORE22	IW	MISSION ELAPSED TIME (FRAME COUNTER)
16	AFELESTK	EW	PITCH STICK
17	AFAILSTK	EW	ROLL STICK
18	AFRUDPED	EW	RUDDER
19	ADTHRL	EW	LEFT THROTTLE
20	ADTHRR	EW	RIGHT THROTTLE
21	RVR	PH	VISIBILITY (PACKED: RVR;IH + FVR;IH)
22	EFWONWSW	PB	WEIGHT ON WHEELS (PACKED:N,M,L,R IN & CONSECUTIVE BYTES)
23	AVXIMM1	ED	C-130 LATITUDE (FIRST WORD)
24	AVYIMM1		" (SECOND WORD)
25	AVO1MM1	ED	C-130 LONGITUDE (FIRST WORD)
26	AVO2MM1		" (SECOND WORD)
27	AVZ1MM1	EW	C-130 ALTITUDE
28	AVTHEMM1	EW	C-130 PITCH
29	AVPHIMM1	EW	C-130 ROLL
30	AVPSIMM1	EW	C-130 YAW
31	AV03MM1	EW	C-130 VELOCITY
32		PB	L. ENG FAIL/R. ENG FAIL/MANUAL REV (PACKED: EEMFFOL;LB + EEMFFOR;LB + EFFCNORM;LB)
33	AFVI	EW	INDICATED AIRSPEED
34		PB	APU STRT/CROSS FEED/APU GEN/SAS YAW(PACKED: EFAPUSTR + EFCRSFED + EFAPUGEN + EFYSASR)

RAW SIMULATOR DATA RECORDED DURING TASK TWO
CHEMICAL WARFARE DEFENSE STUDY

Task Two: Eight (8) minutes duration. Initialized in the air behind a KC-135 tanker with the objective to perform a refueling operation, taking on fuel for as long as possible in this task period.

WORD	DATAPOOL NAME	TYPE	PARAMETER DESCRIPTION
1	WNALATDP	ED	A/C LATITUDE (FIRST WORD)
2			" (SECOND WORD)
3	WNALONDP	ED	A/C LONGITUDE (FIRST WORD)
4			" (SECOND WORD)
5	AFHGEO	EW	A/C ALTITUDE
6	AFUE	EW	A/C X VELOCITY (EARTH)
7	AFVE	EW	A/C Y VELOCITY (EARTH)
8	AFWE	EW	A/C Z VELOCITY (EARTH)
9	AFDUE	EW	A/C X ACCELERATION (EARTH)
10	AFDVE	EW	A/C Y ACCELERATION (EARTH)
11	AFDWE	EW	A/C Z ACCELERATION (EARTH)
12	AFGTHETA	EW	A/C PITCH ANGLE
13	AFGPHI	EW	A/C ROLL ANGLE
14	AFGPSI	EW	A/C YAW ANGLE (HEADING WRT TRUE NORTH)
15	BSCORE22	IW	MISSION ELAPSED TIME (FRAME COUNTER)
16	AFELESTK	EW	PITCH STICK
17	AFAILSTK	EW	ROLL STICK
18	AFRUDPED	EW	RUDDER
19	ADTHRL	EW	LEFT THROTTLE
20	ADTHRR	EW	RIGHT THROTTLE
21	RVR	PH	VISIBILITY (PACKED: RVR;IH + FVR;IH)
22	AVXIMM2	ED	TANKER LATITUDE (FIRST WORD)
23	AVYIMM2		" (SECOND WORD)
24	AVO1MM2	ED	" LONGITUDE (FIRST WORD)
25	V02MM2		" " (SECOND WORD)
26	AVZIMM2	EW	"ALTITUDE
27	AVTHEMM2	EW	"PITCH
28	AVPHIMM2	EW	"ROLL
29	AVPSIMM2	EW	"YAW
30	AVO3MM2	EW	"VELOCITY
31	AVXIMM3	ED	BOOM HINGE LATITUDE (FIRST WORD)
32	AVYIMM3		" (SECOND WORD)
33	AVO1MM3	ED	"LONGITUDE (FIRST WORD)
34	AV02MM3		" " (SECOND WORD)
35	AVZIMM3	EW	" ALTITUDE
36	AVTHEMM3	EW	" PITCH
37	AVPSIMM3	EW	" YAW
38	AFXGOAL	EW	RECEPTACLE TO BOOM TIP AFT SEPARATION
39	AFYGOAL	EW	" LATERAL SEPARATION
40	AFZGOAL	EW	" VERTICAL SEPARATION

RAW SIMULATOR DATA RECORDED DURING TASK THREE
CHEMICAL WARFARE DEFENSE STUDY

Task Three: Twelve (12) minutes duration. Initialized on a gunnery range at an altitude of 5,500 ft MSL, with the objective to perform conventional strafing runs on a conventional target panel on the ground.

WORD	DATAPOOL NAME	TYPE	PARAMETER DESCRIPTION
1	WNALATDP	ED	A/C LATITUDE (FIRST WORD)
2			" (SECOND WORD)
3	WNALONDP	ED	A/C LONGITUDE (FIRST WORD)
4			" (SECOND WORD)
5	AFHGEO	EW	A/C ALTITUDE
6	AFUE	EW	A/C X VELOCITY (EARTH)
7	AFVE	EW	A/C Y VELOCITY (EARTH)
8	AFWE	EW	A/C Z VELOCITY (EARTH)
9	AFDUE	EW	A/C X ACCELERATION (EARTH)
10	AFDVE	EW	A/C Y ACCELERATION (EARTH)
11	AFDWE	EW	A/C Z ACCELERATION (EARTH)
12	AFGTHETA	EW	A/C PITCH ANGLE
13	AFGPHI	EW	A/C ROLL ANGLE
14	AFGPSI	EW	A/C YAW ANGLE (HEADING WRT TRUE NORTH)
15	BSCORE22	IW	MISSION ELAPSED TIME (FRAME COUNTER)
16	AFELESTK	EW	PITCH STICK
17	AFAILSTK	EW	ROLL STICK
18	AFRUDPED	EW	RUDDER
19	ADTHRL	EW	LEFT THROTTLE
20	ADTHRR	EW	RIGHT THROTTLE
21	RVR	PH	VISIBILITY (PACKED: RVR;IH + FVR;IH)
22		PB	FIRE RATE SWITCHES/TRIGGER (PACKED: EWGRHI;LB + EWGRLO;LB + EWTRIGER;LB)
23	AFNORNDS	EW	ROUNDS REMAINING
24	HUDDEPR	IW	HUD DEPRESSION
25	TERRNHGT	EW	TERRAIN HEIGHT ABOVE SEA LEVEL (DIRECTLY BENEATH OWNSHIP)
26	AFVI	EW	INDICATED AIRSPEED
27	AF30	ED	IMPACT DATA LATITUDE (WORD 1)
28	AF31		" " " (WORD 2)
29	AF32	ED	IMPACT DATA LONGITUDE (WORD 1)
30	AF33		" " " (WORD 2)
31	AF34	EW	IMPACT DATA ALTITUDE
32	AF35	IW	NUMBER AVERAGED FOR 10 HERTZ
33	AF36	PB	(4 BYTES) BUCKETS HIT IN 10 HERTZ
34	AF37	PB	" " " " " "
35	AF38	IW	TOTAL NUMBER OF ROUNDS PER PASS
36	BARBDTOT	IW	NUMBER OF ROUNDS PER BURST

RAW SIMULATOR DATA RECORDED DURING TASK FOUR CHEMICAL WARFARE DEFENSE STUDY

Task Four: Twenty (20) minutes duration. Perform low-level navigation tasks for ingress to the Red Flag threat area and then warfare tactics tasks, in the Red Flag threat area, between the A-10 aircraft simulator and the various simulated threats and targets.

WORD	DATAPOOL NAME	TYPE	PARAMETER DESCRIPTION
1	WNLATDP	ED	A/C LATITUDE (FIRST WORD)
2			" (SECOND WORD)
3	WNALONDP	ED	A/C LONGITUDE (FIRST WORD)
4			" (SECOND WORD)
5	AFHGEO	EW	A/C ALTITUDE
6	AFUE	EW	A/C X VELOCITY (EARTH)
7	AFVE	EW	A/C Y VELOCITY (EARTH)
8	AFWE	EW	A/C Z VELOCITY (EARTH)
9	AFDUE	EW	A/C X ACCELERATION (EARTH)
10	AFDVE	EW	A/C Y ACCELERATION (EARTH)
11	AFDWE	EW	A/C Z ACCELERATION (EARTH)
12	AFGTHETA	EW	A/C PITCH ANGLE
13	AFGPHI	EW	A/C ROLL ANGLE
14	AFGPSI	EW	A/C YAW ANGLE (HEADING WRT TRUE NORTH)
15	BSCORE22	IW	MISSION ELAPSED TIME (FRAME COUNTER)
16	AFELESTK	EW	PITCH STICK
17	AFAILSTK	EW	ROLL STICK
18	AFRUDPED	EW	RUDDER
19	ADTHRL	EW	LEFT THROTTLE
20	ADTHRR	EW	RIGHT THROTTLE
21	RVR	PH	VISIBILITY (PACKED: RVR;IH + FVR;IH)
22		PB	FIRE RATE SWITCHES/TRIGGER (PACKED: EWGRHI;LB + EWGRLO;LB + EWTRIGER;LB)
23	AFNORNDS	EW	ROUNDS REMAINING
24	HUDDEPR	IW	HUD DEPRESSION
25	TERRNHGT	EW	TERRAIN HEIGHT ABOVE SEA LEVEL (DIRECTLY BENEATH OWNSHIP)
26	AFVI	EW	INDICATED AIRSPEED
27	BSCORE16	PB	AAA STATUS (PACKED: AAA1;IB + AAA2;IB + AAA3;IB + AAA4;IB)
28	BSCORE24	PB	AAA STATUS (PACKED: AAA5;IB + AAA6;IB + # OWNSHIP KILLED;1B + NOT USED;IB)
29	BSCORE17	PB	SAM STATUS (PACKED: SAM1;IB + SAM2;IB + SAM3;IB + SAM4;IB)
30	BSCORE18	PB	SAM STATUS (PACKED: SAM5;IB + SAM6;IB + SAM7;IB + SAM8;IB)
31	BSCORE19	IW	# OF OWNSHIP KILLS BY SAMS
32	BSCORE15	IW	# OF TARGETS KILLED BY OWNSHIP
33	BSCORE21	IW	MODEL ID OF THE TARGET KILLED
34	BARNDTOT	IW	NUMBER OF ROUNDS PER BURST

APPENDIX D: BIBLIOGRAPHY

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*U.S. GOVERNMENT PRINTING OFFICE 1992-0-461-049-60024